

National Park Service
U.S. Department of the Interior
Air Resources Division



Air Quality in the National Parks

Second Edition

Air Quality in the National Parks - Second Edition





Air Quality in the National Parks

Second Edition

National Park Service Air Resources Division
Lakewood, Colorado

U.S. Department of the Interior
Washington, DC

(Cover) Grand Canyon National Park, Arizona

(Left) Crater Lake National Park, Oregon

Acknowledgments

The National Park Service expresses appreciation and acknowledges the many park employees, contractors, universities, and other federal and state agencies that have assisted in the collection of air quality monitoring and research data in our national parks. Also acknowledged are the following individuals who contributed to each of the chapters as authors or co-authors: Dee Morse, John Ray, Mark Scruggs, Chris Shaver, John Bunyak, Kathy Tonnessen, Jim Renfro, Tonnie Maniero, Dave Joseph, Tamara Blett, and Kristi Morris. Thanks also go to Gloria Mercer, of Air Resource Specialists, Inc., for formatting the report and assisting in its publication. The National Park Service also acknowledges Miguel Flores whose hard work and dedication made this publication into a complete and comprehensible report. The National Park Service appreciates the assistance provided by all of the reviewers.

Disclaimer

Mention of trade names or commercial products in this report does not constitute endorsements or recommendations for use by the National Park Service.

D-2266 September 2002

Printed on recycled paper 



“Mount Rainier is the undisputed icon of the Pacific Northwest and the public is passionate about ‘their’ park and its protection. Mount Rainier dominates the horizon and can be seen daily by millions of people. When the mountain is out, the people come and they expect clean air and panoramic vistas. The views, however, are often tarnished by the haze generated in the Puget Sound area. Because of this unique position, the quality of the air around Mount Rainier National Park serves to galvanize support among all the interest groups, governments, and the general public into actions that protect the entire region.”

*Jon Jarvis, Superintendent
Mount Rainier National Park, Washington*

Contents

Executive Summary vi

Chapter One

Preserving Air Quality in National Parks 1

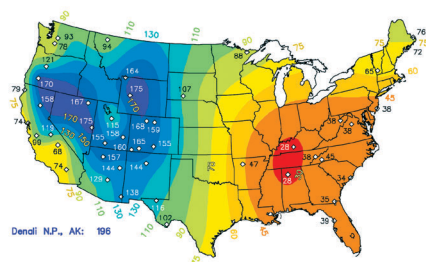
Our mandate	1
Air pollution effects	1
Management policies	2
Understanding the impact of air pollution on national parks	2
<i>Pollutants of concern, their impact, and resources at risk</i>	3
<i>Sources of air pollutants</i>	4
<i>Measuring air pollutant levels in parks</i>	4
<i>Visibility monitoring</i>	4
<i>Atmospheric deposition monitoring</i>	4
<i>Gaseous pollutant and meteorological monitoring</i>	5
<i>Pollutant transport</i>	5
Meeting our affirmative responsibilities	6
<i>Communication</i>	6
<i>Consultation</i>	6
<i>Motor vehicle standards</i>	7
<i>Eastern states nitrogen oxides state implementation plan order</i>	7
<i>Regional haze regulations</i>	7
<i>Air quality related value restoration and protection rulemaking</i>	8
<i>Cooperation</i>	8
<i>Conservation</i>	8



Chapter Two

Current Air Quality Conditions and Trends 9

Visibility	9
<i>Current visibility conditions</i>	9
<i>Causes of visibility impairment</i>	10
<i>Visibility trends</i>	13
Atmospheric deposition	16
<i>Critical loads and target loads</i>	16
<i>Atmospheric deposition levels</i>	17
<i>Sulfate, nitrate, and ammonium in precipitation</i>	17
<i>Trends in sulfate and nitrogen concentrations in precipitation</i>	19
Ozone and its effects	21
<i>Ozone and its ecological effects</i>	21
<i>Ozone and visitor and employee health</i>	23
<i>Ozone trends</i>	24
Other gaseous pollutants	26



Chapter Three

Measuring Air Quality in National Parks 27

Visibility monitoring	28
Acid precipitation and deposition monitoring	29
Ecosystem monitoring	30
Lake, stream, and watershed monitoring	31
Gaseous pollutant and meteorological monitoring	31
<i>Ozone passive sampling</i>	31
Air pollution special studies	32
<i>Big Bend Regional Aerosol and Visibility Observational Study (BRAVO)</i>	32
<i>Winter Haze Intensive Tracer Experiment (WHITEX)</i>	33
<i>Measurement of Haze and Visual Effects (MOHAVE)</i>	33
<i>Pacific Northwest Regional Visibility Experiment Using Natural Tracers (PREVENT)</i>	33
<i>Centralia Power Plant Collaborative Decision-Making Process</i>	33
Human perception and values	34
Gaseous pollutant special studies	34



Chapter Four

Great Smoky Mountains National Park -- Threatened by Air Pollution 35

Resources under stress 36

Visibility impairment from regional haze 36

Atmospheric deposition impacts to terrestrial and aquatic ecosystems 37

Ozone pollution and its impacts 39

Air quality monitoring and research activities 42

Southeastern Aerosol and Visibility Study (SEAVS) 42

Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet) 42

Research on ozone damage to the growth and physiology of native trees and wildflowers 42

Southern Appalachian Mountains Initiative (SAMI) 43

Public awareness: a key to success 43

Partnerships 43

Public awareness and education: "keep telling the story" 43



Chapter Five

The Future of Air Quality in Our National Parks 45

Background 45

Future air quality challenges 45

Challenges 45

Visibility 46

Atmospheric deposition 46

Ozone and other criteria pollutants 46

Smoke management 46

Toxic air pollutants 46

Park emissions 47

Legislation and regulations 47

Cap and trade programs 47

Science and research 47

Education and outreach 47

A strategy for the future 48

Communicating our message 48

Working with others to improve air quality 48

Environmental leadership 49

In-park emissions 49

Mobile emissions 50

Fire management air issues 50

Energy conservation 50

Responding to the challenge 50



Appendix A

Data Tables 51

Haziness Index in U.S. National Parks for the Clearest Days, 1990 - 1999: Average of Best 20 percent days, in deciviews (dv) 52

Haziness Index in U.S. National Parks for the Haziest Days, 1990 -1999: Average of Worst 20 percent days, in deciviews (dv) 53

Precipitation-Weighted Mean Sulfate Ion Concentration in U.S. National Parks, 1990 - 1999: Annual Average in $\mu\text{eq/liter}$ 54

Sulfate Ion Wet Deposition in U.S. National Parks, 1990 - 1999: Annual Average in kilograms/hectare 55

Precipitation-Weighted Mean Nitrate Ion Concentration in U.S. National Parks, 1990 - 1999: Annual Average in $\mu\text{eq/liter}$ 56

Inorganic Nitrogen Wet Deposition From Nitrate and Ammonium in U.S. National Parks, 1990 - 1999: Annual Average in kilograms/hectare 57

Ozone Levels in U.S. National Parks, 1990 - 1999: Average of the Daily 1-hour Maximum, May-September, in ppb 58

Ozone Levels in U.S. National Parks, 1990 - 1999: Annual 4th Highest 8-hour Average, in ppb 59

Haziness Index in U.S. National Parks for the Clearest Days 1990 - 1999: Average of Best 20 percent days, in deciviews (dv)													
Park	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg	Status Trend
Acadia, ME		10.6	10.7	10.2	10.6	9.8	9.6	9.1	9.7	9.3	8.7	9.8	⬇️
Adirondack, NY		7.6	7.4	7.2	7.4	7.9	6.6	7.9	7.1	7.4	6.6	7.3	⬇️
Bandelier, NM		—	—	—	7	6.7	5.9	6.9	6.3	6.8	6.7	6.5	⬇️
Big Bend, TX		8.4	8.2	7.5	7.7	8.5	7.8	—	6.9	9.3	8.8	8.1	⬇️
Bryce Canyon, UT		5.9	5.0	5.7	4.8	4.5	4.3	4.1	4.6	4.5	4.7	4.7	⬇️
Canyonlands, UT		5.9	6.2	6.3	6	6.5	5.7	4.9	6.0	5.8	5.8	5.9	⬇️
Chiricahua, AZ		—	6.8	6.6	6.4	6.6	6.8	6.4	6.7	6.6	6.4	6.6	⬇️
Crocker-Lewis, OR		—	—	5.1	5.1	—	3.7	4.3	4.3	4.1	4.1	4.4	⬇️
Denali, AK		—	3.5	3.4	3.7	3.4	3.2	3.7	4.1	3.1	3.2	3.5	⬇️
Glacier, MT		8.0	9.8	8.9	9.0	8.5	7.9	8	7.9	8.3	7.5	8.4	⬇️
Grand Canyon, AZ		—	—	—	5.7	5.3	3.9	4.0	4.4	4.8	5.2	5.1	⬇️
Great Basin, NV		5.1	5.5	—	5.1	4.9	5.0	5.1	5.0	5.0	5.3	4.9	⬇️
Great Sand Dunes, CO		6.6	6.7	6.3	6.1	5.4	4.8	4.9	5.3	6.6	5.5	5.8	⬇️
Great Smoky Mts., TN/NC		15.3	13.8	13.6	14.4	13.8	13.5	15.3	15.1	14.4	15.2	14.4	⬇️
Guadalupe Mts., TX		—	—	7.3	8.0	7.5	8.3	7.8	7.2	7.5	7.6	7.7	⬇️
Lassen Volcanic, CA		4.5	4.3	4.7	5.1	4.4	3.9	4.0	4.4	4.3	4.1	4.4	⬇️
Marathon, TX		—	—	10.3	17.3	—	15.5	16	15.8	16.2	16.1	16.3	⬇️
Mesa Verde, CO		5.5	6.1	5.6	5.7	6.3	4.9	5.0	—	5.9	5.7	5.6	⬇️
Monks, WA		—	7.0	7.2	7.5	6.3	5.0	5.4	5.5	5.0	5.3	6.0	⬇️
Petrified Forest, AZ		—	8.0	7.6	6.2	6.2	6.2	6.1	6.9	6.8	6.7	6.7	⬇️
Pinnacles, CA		9.4	9.3	9.1	8.7	9.4	8.3	8.0	8.9	—	8.7	8.9	⬇️
Point Reyes, CA		9.1	8.8	8.6	8.5	8.1	7.8	8.1	—	8.7	8.9	8.8	⬇️
Redwood, CA		6.7	6.8	6.9	6.7	6.3	6.6	5.3	6.1	5.5	6.2	6.3	⬇️
Rocky Mountain, CO		4.3	4.1	3.9	4.5	5.0	4.3	3.9	4.2	4.8	3.9	4.3	⬇️
Shenandoah, VA		14.1	13.4	12.6	14.2	12.3	12.8	14.2	13.5	11.8	11.9	13.1	⬇️
Tonto, AZ		—	8.2	—	7.7	7.2	7.7	7.7	7.6	7.9	8.1	7.7	⬇️
Yellowstone, WY		—	—	5.9	5.2	4.7	4.6	5	—	3.8	4.9	—	⬇️
Yosemite, CA		8.4	5.6	4.8	4.8	4.5	5.3	4.5	5.5	4.7	5.0	5.0	⬇️
Average		7.7	7.5	7.6	7.5	6.9	6.8	6.6	7.2	7.1	7.0	7.2	⬇️
Symbols: "—" indicates insufficient or no data, or no trend													
Park Air Quality Status													
Much Worse than NPS Average													
Worse than NPS Average													
NPS Average													
Better than NPS Average													
Much Better than NPS Average													
Total													
Significant Improvement													
Improvement													
Degradation													
Significant Degradation													
No Trend													
Statistically significant at $\alpha=0.15$													